THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

STUDY OF WAX-IMPREGNATED CORRUGATED BOARD

Project 1108-18

Progress Report Three

to

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

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INTRODUCTION

During the past half century the corrugated and solid fiber box industry has expanded rapidly as a result in part of replacing or substituting for existing container material or creating new uses. It is to the latter that this study is directed. The bulk of the new uses created in the past have been satisfied for the most part by conventional grades of paperboard boxes as we know them today. It is believed that in the immediate future one of its greatest potentials lies in modifying the corrugated box in such a manner as to impart to it qualities which cannot be attained physically or economically with conventional grades of paperboard. For example, the poultry industry constitutes a potential outlet for a very significant tonnage of board provided a box can be developed which will be economically equivalent or better than its competitive wirebound box and which will perform satisfactorily. In 1955 more than 6 billion pounds of live poultry was slaughtered. Approximately 4.3 billion pounds was slaughtered in commercial processing plants and marketed in several forms. Currently, a large percentage of the fresh poultry is shipped from the processing plant to the wholesaler or retail stores as whole eviscerated poultry wet-packed (iced) in wirebound boxes.

The requirements which must be met by a paperboard box for this purpose are quite severe. Basically, it must exhibit sufficient compression strength to keep the load off the poultry and, second, it must have adequate retentive strength in an environment characterized by contact with water in three states of matter, namely, solid (ice), liquid and gaseous.

Many special board combinations with and without special treatment or coatings have been tried in the form of full telescopic boxes for wet-pack poultry. Some of these have exhibited satisfactory performance; however, their costs have been well above the current cost of the wirebound box.

In searching for means of treating corrugated board to impart the qualities necessary to meet the conditions imposed, it has been found that corrugated board can be markedly improved by impregnating the combined board with paraffin wax or any other similar thermoplastic material with the proper viscosity characteristics. The purpose of this report is to present the methods of application and results obtained to date. In brief, the technique consists in applying molten wax to the scored and slotted box blanks either by means of a roll waxer or by hot spraying. Heat is then applied to cause the molten wax to migrate into the inner part of the liner and also the medium by capillarity. This may be brought about by lower temperatures and longer times or shorter exposures at higher temperatures. The first phase of this study, which is the subject of this report, was concerned with determining the most practical method of wax impregnation in keeping with the efficiency of board quality and the comparative performance of treated and untreated board.

GENERAL PROCEDURE

As is well known, the coating or impregnation of paper or paperboard with wax to impart special properties has been used for many years and certainly is not new to the corrugated box industry. However, in applications in the corrugated field heretofore, the wax has been used merely to coat or impregnate the liners. The current application differed in that in the study reported herein, the objective is to add sufficient wax, in the amount of approximately 30%, to the two surfaces of the combined board and then utilize heat in causing the wax to distribute itself uniformly throughout the liners and mediums by capillarity. Heretofore, impregnations to this degree had been attained only by dipping as in the case of the Hollinger box, the combined board in molten wax or wax-resin combination and allowing the board to drain.

IMPREGNATION

Wax Application

The first method tried was to surface coat the scored box blanks with molten wax by means of a roll coater. For this purpose, a one-side roll waxer was used. Since only one side of the board was waxed at a time, it was necessary to turn the board over and run it through the waxer again. It should be mentioned that in order to apply 30% wax it was necessary to make two or three passes through the waxer. For a commercial operation, a two-side roll waxer with possibly a double applicator unit is recommended. The temperature of the wax generally was 140°F. although other temperatures were tried. The blanks were fed to the waxer at room temperature. In an attempt to increase the wax pick-up per pass, the board was preheated to approximately 150°F.; however, the pick-up was less. In the case of the preheated board, the viscosity of the wax on the board apparently was less and, although slightly better penetration of the board was obtained, less wax was retained on the surface, resulting in a lesser over-all wax transfer.

In an attempt to circumvent the processing difficulties associated with obtaining sufficient wax pick-up, another method of waxing was also tried. This method involved spraying the scored blanks with molten wax. The scored blanks were preheated to 200°F. in an oven and then sprayed with wax using a DeVilbers Paint spray gun equipped with a hot spray tip. The air supply to the gun was electrically heated to 150°F. (temperature actually ranged from 150-250°F.). Initial attempts were made to spray the wax with a nonpressurized supply tank; however, insufficient wax was applied. A pressurized supply tank was obtained and attached to the gun. Using a pressure of 5-10 p.s.i. in the supply tank and 45 p.s.i. air at 150°F. at the spray nozzle permitted the proper amount of wax to be applied with the minimum amount of misting. Because of the latter, it was necessary to carry out the spraying in an enclosed area. Any commercial installation should be in an enclosed spray chamber. The wax supply was heated to 180°F. before adding to the supply tank; thus, the actual temperature of application was probably somewhere between 150 and 180°F. The nozzle of the gun was placed approximately 10 inches from the surface of the board.

For purposes of comparison, a few samples were also impregnated by dipping the board in a bath of molten wax at 180°F. The board was immersed for three seconds, withdrawn from the bath and allowed to drain. Some of the samples were preheated prior to dipping, whereas others were dipped at room temperature. There appeared to be no significant difference. After dipping, the samples were placed in an atmosphere maintained at 200°F. and allowed to drain for two hours. In the case of the dipped specimens, it was necessary to place a pan under the board specimens to catch the wax drippings which were quite excessive under the conditions used.

Impregnation

Two methods of driving the wax into the board were used. One method involved the use of infrared radiation at relatively high temperature levels for short periods. The infrared units were adjusted to give surface temperatures of 350, 400, and 450°F. This method required about 15 minutes to cause the wax to melt and migrate into the board leaving a relatively "dry" surface. This method did not appear to be practical for a number of reasons. The high temperature caused the wax on the surface to melt and some of it ran off the surface rather than migrate into the board. Also, it was found that at about 475°F. the wax fumes would ignite. The board treated in this manner did not have a uniform distribution of the wax; in some cases, the medium was not fully impregnated. Finally, the time required was too long to be practical.

The other method of impregnating consisted in placing the wax-coated board in an oven maintained at 180-200°F. The "curing" period varied from 1 to 8 hours. This gave a much more uniform distribution of the wax than the method involving infrared radiation. The oven was constructed of 3/8-inch plywood and lined with fiberglass and sheet aluminum. The oven or "curing" chamber could be used in two ways--i.e., a pile of sheets could be heated by hot air circulated around it or the sheets could be orientated so as to force the hot air through the flutes and thus heat the board more uniformly and more rapidly. It is believed that the latter is the most efficient method and could be utilized in a commercial installation in which skids of wax-treated board could be so treated. This method of impregnation proved to be very effective and resulted in board having a uniform impregnation. No free or liquid wax was found on the sheets at the end of the curing period except in those cases where upward of 60-70% wax was added. Also, at normal applications there was no tendency to block and the surfaces were "dry."

MATERIALS USED

The board material used in this series of experiments consisted of eight samples of corrugated board. The general character of the samples are given in Table I.

TABLE I

Sample Number	Type Board	Grade Combination	Adhesive	Flute
1	Regular	42-26-42	Starch	A
2	Regular	42-26-42	Starch-resin [a]	A
4	Regular	69-33-69	Starch-resin [a]	A
6	Regular	42-26-42	--	A
7	Regular	69-33-69	--	A
8	Weathertex	V_3c	Waterproof	B

[a] Hubinger adhesive.

Sample 1 was obtained from Institute inventory whereas Samples 2-7 were submitted by Gaylord Container Corporation. Samples 2 and 3 represent different shipments of the same nominal grade. The same applies to Samples 4 and 5. The V_3c (Sample 8) was submitted by Union Bag-Camp Paper Corporation.

Samples 1 through 5 were prepared for waxing in a number of ways. Sample 1 which was fabricated from regular components with plain starch adhesive was used in the first series of trials because it was hoped that the presence of the wax would eliminate the need for water-resistant adhesives. The results did not bear this out and subsequent trials were carried out using board fabricated with water-resistant adhesives. Prior to waxing, Sample 1 was scored to make a 12 by 11 by 11-stitched R.S.C. box. As an expediency, the work with Samples 2 to 8 was limited to tubes. Samples 2, 4, and 8 were scored and cut to make tube blanks size 12 by 12 by 12 stitched. Samples 3 and 5, which were a later shipment of the same nominal grades as Samples 2 and 4, were cut on the corrugator such that the tube size had to be reduced to 9 by 9 by 9 inches. Samples 6, 7, and 8 were included for comparison purposes only. Samples 6 and 7 consisted of scored blanks (for 12 by 12 by 12-stitched tube) which had been dipped in a combination of Vinsol and wax. The pick-up was approximately 60%. This type of treated board is used in the form of a tube for reinforcing the compression strength of boxes. The board was so stiff and brittle that it would be impossible to form a satisfactory box out of it with the 60% pick-up. Sample 8 (V_3c) was scored and made into a tube without any wax treatment since its purpose was for comparison.

The wax used for all the impregnation experiments carried out in this study was obtained from Socony Vacuum Oil Co. and is identified as Mobil Wax "D." This particular grade of paraffin has an oil content of 0.2% and a melting point of 127-9°F. The wax appeared to be quite stable up to 200°F.; however, it tended to darken when held for long periods at higher temperatures.

Several preliminary investigations were made to modify the paraffin by the use of additives to give better box performance, especially when wet. Also, trials were made using a solution of paraffin in a solvent in the hopes of getting easier and more uniform distribution of the wax and to avoid "after heating" if possible. The materials used were as follows:

a. Paraffin dissolved in Savasol No. 75--14% solution. Board dipped and drained.

b. Board dipped in mineral oil and allowed to drain.

c. Board dipped in mineral oil and then wax coated with paraffin.

d. Combination of Piccopale 70 and paraffin were used for dipping, in ratios of 5:95 and 20:80. It was necessary to heat resins for several hours at 250°F. in order to dissolve them in the wax.

e. Mixture of 90% paraffin and 10% microcrystalline wax (Socony-Vacuum 2300) was used as an impregnant.

f. Mixture of 5 and 10% polyethylene and paraffin.

EVALUATION

After the samples had been treated they were conditioned for three days in an atmosphere maintained at 50 ± 2% relative humidity at 73 ± 3.5°F. and then stitched into boxes or tubes. Samples 6, 7, and 8 were similarly treated.

Sample 1 was evaluated for box compression only. Box compression tests were performed at the following conditions:

1. After 72 hours at 50% R.H.
2. After 72 hours at 85% R.H.
3. After 10 minutes' immersion in water at 73°F.

In addition, bursting strength and flat-crush determinations were made on the treated board conditioned at 50% R.H.

Samples 2 to 8 were evaluated for tube compression, flat crush, G. E. puncture, and bursting strength. The combined board tests were made only after conditioning at 50% R.H. Tube compression tests were made at 50% R.H. and after 24 and 96 hours' immersion in water. These latter conditions were established by the technical committee created by the Container Research Committee to expedite this study.

DISCUSSION OF RESULTS

As previously mentioned, the main objective of this study was to determine the most practical manner of impregnating corrugated board with paraffin wax to increase its efficiency as a packaging material for the wet-packing of fresh poultry. The board material used was regular liners rather than heavily sized or wet-strength treated. Varying amounts of paraffin applied under different conditions were investigated.

PRELIMINARY EXPERIMENTS

A few exploratory experiments were carried out to investigate in a cursory way the possible use of a combination of paraffin and additives or impregnants other than paraffin. The merits of each were based solely on visual examination and much work needs to be done in this area as it is anticipated that additives may be found which when added to paraffin will substantially improve the performance.

In an attempt to overcome the difficulty of applying the wax and then driving it in with heat, paraffin was dissolved in a solvent (Savasol 75) and then applied to the board, the idea being that the viscosity of such a solution would be materially lower than molten paraffin and complete impregnation would be obtained readily. It was further hoped that the solvent would evaporate and leave the paraffin uniformly distributed rather than migrate to the surface. A number of difficulties were encountered which indicate that this is not practical with the solvent in question. Even after heating to 130°F., only 14% paraffin was dissolved. When this solution was applied to the board, it was absorbed readily by the board, but there was a strong residual odor even after heating for a considerable period of time.

In another experiment, the paraffin was replaced by mineral oil. The resulting board had a greasy film on the surface in contrast to the "dry" feel of board impregnated with paraffin. In an attempt to overcome the greasy film, several samples of the board treated with mineral oil were run through the paraffin machine; however, the paraffin would not transfer because of the mineral oil on the surface of the board.

Other experiments were tried using combinations of Piccopale 70 resin and paraffin. It was found that this mixture had to be heated for several hours at 250°F. in order to obtain complete mixing. Samples dipped in these mixtures did not drain well and all had an excess of impregnant on the surface.

Two additional wax combinations were tried. One was a combinaation of microcrystalline wax and paraffin, and the other was polyethylene and paraffin. Ten per cent microcrystalline wax was added to the paraffin in the hope that the microcrystalline wax would impart greater flexibility to the treated board and thereby help the strength at the scoreline. It is felt that when a paraffined and scored sheet is folded as in setting up the box, the paraffin wax shatters or cracks in the area of the scoreline, thereby allowing water to penetrate more readily and thus reducing the retentive strength of the box. Samples treated with 10% microcrystalline and 90% paraffin exhibited a tacky film although the film appeared to be less brittle. It is believed that this area warrants further study using a less tacky microcrystalline wax. When the board was impregnated with a mixture of polyethylene and paraffin in the ratios of 10:90 and 5:95, there was a noticeable increase in the apparent board stiffness and the surface of the board was harder.

The main disadvantage of polyethylene is the cost, it being about four or five times the cost of the paraffin. The results of the cursory investigation indicate that further study should be devoted to the possible application of this mixture. For example, it may be possible to combine paraffin, petrolatum and polyethylene in such a manner as to obtain the physical benefits without much if any increase in cost since petrolatum is much cheaper than paraffin, whereas polyethylene is more expensive than paraffin. The polyethylene will have a higher viscosity than the paraffin, whereas the petrolatum will have a lower viscosity.

SAMPLE 1--REGULAR BOARD FABRICATED WITH REGULAR STARCH ADHESIVE

As may be recalled, the initial investigation using various amounts of paraffin and different methods of application was carried out on Sample 1 which was a 42-26-42 combination fabricated with regular adhesive. In the case of Sample 1, the wax was applied by means of a roll waxer. Three different application temperatures--i.e., 140, 200 and 250°F.--were tried using different degrees of pick-up. The impregnation was all done by means of infrared radiations at temperature levels of 350, 400 and 450°F. The conditions used and the compression results obtained on the boxes are given in Table II together with the combined board tests. It may be noted from the results obtained at 50% R.H. that the boxes made from the wax-impregnated board exhibited compression strengths 30-45% higher than the untreated. The compression strength increased with increases in the amount of wax; however, the improvement in strength was insignificant in comparison to the percentage increase in wax. The temperature at which the wax was applied and the temperature of impregnating do not appear to be critical from a compression

TABLE II

COMPARISON OF RESULTS ON TREATED AND UNTREATED BOARD AND BOXES

[Sample 1 (42-26-42)]

Type of Treatment	Wax Pickup, %	Box Compression Results: 50% R.H., Load, lb.	Box Compression Results: 50% R.H., Defl., in.	Box Compression Results: 85% R.H. Load, lb.	Box Compression Results: 85% R.H. Defl., in.	Box Compression Results: 10-Min. Water Immersion Load, lb.	Box Compression Results: 10-Min. Water Immersion Defl., in.	Combined Board Results: Bursting Strength, p.s.i. gage 50% R.H.	Combined Board Results: Flat Crush, p.s.i. gage 50% R.H.
Untreated		990	0.74	335	0.64	*	*	250	29.8
Wax coated at 140°F.									
Impregnated at 350°F.	20	1280	0.70	565	0.66	80	0.17	279	31.6
Impregnated at 350°F.	35	1320	0.74	710	0.76	235	0.41	265	38.0
Impregnated at 400°F.	35	1310	0.68	640	0.64	195	0.42	234	38.8
Impregnated at 450°F.	35	1310	0.75	740	0.76	200	0.46	285	36.8
Impregnated at 400°F.	50	1455	0.79	730	0.70	230	0.50	252	40.0
Wax coated at 200°F.									
Impregnated at 350°F.	35	1390	0.76	635	0.64	190	0.40	242	38.8
Impregnated at 400°F.	35	1275	0.69	615	0.80	170	0.29	251	35.6
Impregnated at 450°F.	35	1290	0.79	615	0.66	190	0.46	246	35.9
Wax coated at 250°F.									
Impregnated at 400°F.	35	1330	0.73	700	0.66	180	0.40	244	36.6

* These samples completely delaminated after about 5 minutes water immersion due to adhesive failure.

TABLE III

COMPARISON OF TREATED AND UNTREATED TUBES AND BOARDS

Treatment	Wax Content, %	Tube Compression Results (Tube size, 12x12x12): 50% R.H. Load, lb.	50% R.H. Defl., in.	Water Immersion 24 hr. Load, lb.	Water Immersion 24 hr. Defl., in.	Water Immersion 96 hr. Load, lb.	Water Immersion 96 hr. Defl., in.	Combined Board Results: Bursting Strength, p.s.i. gage, 50% R.H.	Bursting Strength, Water Immersion, 24 hr.	Bursting Strength, Water Immersion, 96 hr.	G. E. Puncture, units, 50% R.H.	G. E. Puncture, Water Immersion, 24 hr.	G. E. Puncture, Water Immersion, 96 hr.	Flat Crush, p.s.i., 50% R.H.	Flat Crush, Water Immersion, 24 hr.	Flat Crush, Water Immersion, 96 hr.
Sample 2 (42-26-42)	--	1455	0.08	90	0.04	55	0.02	259	42	36	232	53	49	32.6	2.7	0.0
Coated at 140°F.																
Impregnated at 350°F.	23.3	1910	0.08	180	0.08	190	0.06	240	37	38	221	89	93	30.8	4.0	4.0
Impregnated at 400°F.	20.6	1990	0.06	185	0.07	160	0.07	276	42	38	219	100	94	38.2	4.3	3.6
Impregnated at 450°F.	21.2	1955	0.06	195	0.06	180	0.06	236	41	38	224	98	92	41.7	4.1	4.2
Impregnated at 350°F.	25.5	--	--	190	0.07	175	0.07	--	46	43	--	104	100	--	5.6	5.5
Impregnated at 400°F.	22.0	--	--	180	0.07	190	0.08	--	45	42	--	99	99	--	3.3	4.7
Impregnated at 450°F.	21.1	--	--	190	0.06	170	0.07	--	43	41	--	101	93	--	5.0	4.2
Impregnated at 350°F.	27.0	1980	0.08	210	0.07	180	0.06	229	39	36	219	96	96	40.7	3.6	3.7
Impregnated at 400°F.	26.6	2000	0.07	185	0.06	190	0.06	297	48	40	228	108	100	40.2	4.1	5.3
Impregnated at 450°F.	24.5	1740	0.07	220	0.06	200	0.07	230	46	41	223	104	102	39.4	4.2	4.1
Impregnated at 350°F.	30.4	2140	0.07	185	0.07	190	0.07	231	42	42	231	104	102	42.4	4.5	5.2
Impregnated at 400°F.	28.7	1980	0.08	215	0.06	185	0.06	237	49	40	229	112	105	41.1	4.6	5.7
Impregnated at 450°F.	29.8	2090	0.08	205	0.08	230	0.06	248	47	43	223	106	105	40.7	4.5	4.7
Impregnated at 350°F.	32.4	2245	0.06	215	0.08	185	0.06	224	43	39	230	108	105	43.5	4.6	4.4
Impregnated at 400°F.	34.9	2275	0.07	230	0.06	215	0.07	227	54	42	227	116	113	44.2	5.6	5.0
Impregnated at 450°F.	32.5	2090	0.07	190	0.06	235	0.06	243	50	42	232	108	106	43.8	4.8	4.8
Impregnated at 350°F.	36.4	--	--	205	0.07	225	0.07	--	49	45	--	108	110	--	4.9	4.8
Impregnated at 400°F.	36.9	--	--	240	0.07	200	0.06	--	44	47	--	109	112	--	6.0	5.8
Impregnated at 450°F.	34.4	--	--	210	0.08	210	0.06	--	52	51	--	118	110	--	5.0	5.6

(Continued on the following page)

TABLE III—Continued

COMPARISON OF TREATED AND UNTREATED TUBES AND BOARDS

Treatment	Wax Content, %	Tube Compression Results (Tube size, 12x12x12): 50% R.H. Load, lb.	50% R.H. Defl., in.	Water Immersion 24 hr. Load, lb.	Water Immersion 24 hr. Defl., in.	Water Immersion 96 hr. Load, lb.	Water Immersion 96 hr. Defl., in.	Combined Board Results: Bursting Strength, p.s.i. gage, 50% R.H.	Bursting Strength, Water Immersion, 24 hr.	Bursting Strength, Water Immersion, 96 hr.	G. E. Puncture, units, 50% R.H.	G. E. Puncture, Water Immersion, 24 hr.	G. E. Puncture, Water Immersion, 96 hr.	Flat Crush, p.s.i., 50% R.H.	Flat Crush, Water Immersion, 24 hr.	Flat Crush, Water Immersion, 96 hr.
Sample 2, 42-26-42																
Untreated	—	1455	0.08	90	0.04	55	0.02	259	42	36	232	53	49	32.6	2.7	0.0
Coated at 140°F.																
Not impregnated[a]	22.4	1750	0.07	130	0.07	100	0.05	277	41	43	261	64	60	Insufficient sample	2.6	Insuffi. Sample
Not impregnated[a]	37.7	1740	0.08	125	0.06	90	0.03	246	44	40	269	62	57	"	2.7	"
Oven cured 4 hr. 185°F.	23.5	1955	0.08	170	0.08	175	0.07	204	41	41	265	105	101	"	4.5	4.8
Oven cured 8 hr. 200°F.	23.5	1865	0.07	195	0.08	180	0.07	212	44	42	235	104	102	"	5.9	5.2
Oven cured 4 hr. 185°F.	38.1	2230	0.07	210	0.07	175	0.06	214	45	46	248	109	106	"	5.1	5.9
Oven cured 8 hr. 200°F.	36.6	2050	0.08	220	0.07	205	0.08	219	48	47	234	125	113	"	5.8	5.6
Sample 4, 69-33-69																
Untreated	—	1965	0.09	130	0.05	80	0.05	384	63	53	317	92	80	36.0	3.2	0.8
Coated at 140°F.																
Impregnated at 400°F.	18.4	—		250	0.08	185	0.06	—	53	48	—	155	64	—	3.5	5.2
Impregnated at 400°F.	35.2	—		240	0.06	285	0.06	—	76	74	—	193	194	—	6.7	6.7
Sample 4, 69-33-69																
Untreated	—	1965	0.09	130	0.05	80	0.05	384	63	53	317	92	80	36.0	3.2	0.8
Coated at 140°F.																
Not impregnated[a]	40.1	2385	0.09	156	0.06	120	0.06	318	70	54	340	121	100	Insufficient sample	3.4	2.8
Oven cured 4 hr. 185°F.	20.3	2910	0.08	250	0.06	180	0.08	257	62	55	303	164	146	"	5.4	5.4
Oven cured 8 hr. 200°F.	20.2	2710	0.07	255	0.06	220	0.06	266	61	71	283	168	181	"	5.6	6.4
Oven cured 4 hr. 185°F.	38.6	3220	0.08	205	0.07	285	0.07	264	72	68	301	185	92	"	7.6	6.6
Oven cured 8 hr. 200°F.	38.5	2979	0.07	380	0.08	345	0.09	239	74	75	287	207	189	"	7.9	11.1

[a] Wax coated—no attempt was made to drive the wax into the board beyond what took place on roll waxer.

(Continued on the following page)

TABLE III--Continued

COMPARISON OF TREATED AND UNTREATED TUBES AND BOARDS

Treatment	Wax Content, %	Tube Compression Results (Tube size, 12x12x12): 50% R.H. Load, lb.	50% R.H. Defl., in.	Water Immersion 24 hr. Load, lb.	Water Immersion 24 hr. Defl., in.	Water Immersion 96 hr. Load, lb.	Water Immersion 96 hr. Defl., in.	Combined Board Results: Bursting Strength, p.s.i. gage 50% R.H.	Bursting Strength Water Immersion, 24 hr.	Bursting Strength Water Immersion, 96 hr.	G. E. Puncture, units 50% R.H.	G. E. Puncture Water Immersion, 24 hr.	G. E. Puncture Water Immersion, 96 hr.	Flat Crush, p.s.i. 50% R.H.	Flat Crush Water Immersion, 24 hr.	Flat Crush Water Immersion, 96 hr.
Gaylord Special 42-26-42 A-flute approx. 60% dip-coated Vinsol & wax		3919	0.12	470	0.06	490	0.07	237	166	146	332	293	291	--	15.0	19.2
69-33-69 A-Flute approx. 60% dip-coated Vinsol & wax		2428	0.09	490	0.07	380	0.08	183	98	84	250	165	162	--	19.5	13.6
V_3c B-flute		1425	0.10	70	0.04	--		558	215	--	356	163	--	26.9	Complete adhesion failure	

TABLE IV

COMPARISON OF TREATED AND UNTREATED TUBES AND BOARDS

Treatment	Wax Content, %	Tube Compression Results (Tube size, 9x9x9): 50% R.H. Load, lb.	50% R.H. Defl., in.	Water Immersion 24 hr. Load, lb.	Water Immersion 24 hr. Defl., in.	Water Immersion 96 hr. Load, lb.	Water Immersion 96 hr. Defl., in.	Combined Board Results: Jumbo Mullen Burst, points 50% R.H.	Jumbo Mullen Burst, Water Immersion 24 hr.	Jumbo Mullen Burst, Water Immersion 96 hr.	G. E. Puncture, units 50% R.H.	G. E. Puncture, Water Immersion, 24 hr.	G. E. Puncture, Water Immersion, 96 hr.	Flat Crush, p.s.i. 50% R.H.	Flat Crush, Water Immersion 24 hr.	Flat Crush, Water Immersion 96 hr.
Sample 3																
42-26-42 A-flute Combined Board																
Untreated	--	1325	0.06	80	0.04	75	0.05	240	38	42	213	59	58	30.0	2.3	2.3
Wax sprayed	6.8	1440	0.06	125	0.04	110	0.06	216	37	35	202	82	78	36.0	3.7	3.6
	28	1770	0.07	220	0.06	210	0.06	221	51	48	239	126	113	38.5	5.7	5.2
	33			170	0.07											
	47	2170	0.08	285	0.05	275	0.07	200	65	59	226	142	136	53.3	7.7	8.4
	54	2130	0.08	320	0.06	290	0.07	204	67	62	222	150	144	51.3	8.7	8.7
	66	2020	0.07	260	0.08											
Sample 5																
69-33-69 A-flute Combined Board																
Untreated	--	1975	0.08	160	0.06	140	0.06	338	65	60	343	105	94	34.3	3.1	2.9
Wax sprayed	4.4	2040	0.06	210	0.06	180	0.07	302	51	49	309	126	115	38.1	4.3	4.2
	22	2620	0.08	350	0.08	330	0.08	284	70	64	309	186	186	38.2	5.7	5.6
	37	2650	0.09	390	0.08	400	0.08	299	95	79	321	220	212	53.3	7.4	9.0
	48	2630	0.08	505	0.08	500	0.08	268	107	94	215	244	227	61.5	9.7	9.4
	59	3225	0.09	590	0.08	500	0.08	238	122	109	312	247	250	68.2	12.7	11.8
Sample 3																
42-26-42 A-flute Combined Board																
Wax dipped and drained at 80°F.*	50	2180	0.06	265	0.06	240	0.06	151	78	51	236	211	139	66.1	7.2	5.9
Wax dipped and oven cured for 4 hr. at 180°F.	43	2130	0.06	250	0.06	220	0.06	205	43	45	249	119	110	48.8	6.1	5.6
Sample 5																
69-33-69 A-flute Combined Board																
Wax dipped & drained at 80°F.*	47	2995	0.07	475	0.06	440	0.07	250	153	97	352	295	235	78.0	8.1	8.1
Wax dipped & oven cured for 4 hr. at 180°F.	44	3120	0.07	480	0.07	425	0.07	278	87	79	337	220	198	62.1	9.7	8.6

* Heavy excess of wax on surface of sheet.

standpoint. From an operational standpoint the lower temperatures are recommended.

When the results at 85% R.H. are considered, it may be seen that they are 70-120% higher than the untreated box. The higher the wax content in general, the higher the compression strength, although the rate of strength improvement is very low per per cent wax added.

The untreated sample immersed in water for 10 minutes delaminated; thus, no box compression tests could be made. The samples treated with wax exhibited from 80 to 235-pound compression values. It is felt that had a waterproof adhesive been used probably higher results would have been obtained. It should be emphasized that these results were obtained on regular board and not sized board.

The combined board tests on the treated samples were for the most part equal to or better than those obtained on the untreated sample.

CORRUGATED BOARD FABRICATED WITH WATER-RESISTANT ADHESIVE

It may be recalled that the combined board material used in this phase consisted of two sample lots of 42-26-42 (Samples 2 and 4), two sample lots of 69-33-69 (Samples 3 and 5), one sample of 42-26-42 Vinsol-Wax hot dipped (Sample 6), one sample of 69-33-69 Vinsol-wax hot dipped (Sample 7) and one sample of V_3c (Sample 8). Samples 3 and 4 were used in all impregnation experiments until they were exhausted and then Samples 3 and 5 were used. Samples 3 and 5 were cut to the wrong size; thus, it was necessary to test these as 9 by 9 by 9 tubes rather than as the others, namely, 12 by

12 by 12. In the case of Samples 2 and 4, the paraffin wax was applied by means of a roll waxer and impregnated by means of infrared radiation or heating in an oven. In keeping with the request of the committee established to follow the work, the tubes were evaluated under the following conditions:

1. Conditioned at 50% R.H.
2. Immersed for 24 hours in water at 73°F.
3. Immersed for 96 hours in water at 73°F.

It should be emphasized that these conditions are far more severe than would be encountered in the wet-packing of poultry. Secondly, the evaluation procedure speaks only to compression strength and does not consider retention strength--ability to retain the contents. The results obtained under these conditions are given in Table III.

When the tube compression results at 50% are considered, it may be seen that the results at 20% pick-up were only slightly lower than at 30-35% pick-up. As was noted previously, the reimpregnated samples exhibited substantially higher tube compression value than did the untreated.

When the results after 24 hours' immersion are considered, it may be seen that on the 42-26-42 board with approximately 20-25% wax tube compression values were 200% higher than the results for the untreated or the V_3c. It should be mentioned that the V_3c submitted did not have satisfactory adhesion. The same may be said of the 42-26-42 board which was fabricated with Hubinger adhesive. The 42-26-42 board dipped in Vinsol wax exhibited a value 150% higher. The same general trend may be observed for the 69-33-69 samples.

After 96 hours' immersion in water, the untreated samples had lost about half the compression strength exhibited after 24 hours' soaking. The V_3c delaminated and no tests were made. In general, the wax-impregnated samples as well as the Vinsol wax-dipped samples exhibited only a slight decrease in compression strength; thus, it appears that the greatest loss in strength occurs in the first 24 hours. The results for the Vinsol wax-dipped 42-26-42 samples after 96 hours' immersion do not appear to be in line with the other data and are therefore questionable.

In general, the coated samples impregnated in the oven at a temperature of 180 to 200°F. gave about the same results as those impregnated by infrared radiation.

When the combined board results are considered, it may be seen that the treated and untreated sample exhibited test values of the same relative magnitude at 50% R.H. After immersion, the treated samples were generally substantially stronger.

The results obtained on 9 by 9 by 9-inch tubes made from treated and untreated samples of board using Samples 3 and 5 as base stock are given in Table IV. Two methods of impregnating were used. One method involved applying the wax by means of hot-spraying and then impregnating in the oven at 180 to 200°F. The other method consisted in dipping the board and then allowing it to drain a short time before curing in the oven at 180 to 200°F. It should be emphasized that although Samples 3 and 5 were made with Hubinger adhesive, the adhesion was unsatisfactory when immersed in water. The results tabulated in Table IV indicate the same general trend noted in earlier trials.

The results obtained with the hot spray applications were about the same as were obtained when the board was dipped and oven cured.

SUMMARY

It has been found that if a corrugated board is coated on both sides with wax and then heated above the melting point of the wax, the latter will migrate by capillary action not only into the liners but also the corrugated medium. An exploratory study has been carried out for the purpose of investigating the merits of board so treated for purposes, such as the wet packing of fresh poultry, which will extend the corrugated board market. The study reported herein was undertaken with a twofold objective, (a) to determine the most practical method for impregnating corrugated board and (b) to determine the comparative performance of corrugated board impregnated by different methods and to different degrees with the performance of three special samples submitted for comparison purposes. The three special samples consisted of a 42-26-42 and a 69-33-69, both impregnated with approximately 60% Vinsol-wax, and a V_3c. In addition, a few exploratory trials were also made with paraffin and extenders or additives as well as paraffin substitutes.

Two main methods of applying the wax were used. One consisted in two side wax coating of scored box blanks on a roll waxer. The other method utilized a hot wax spray technique for applying the wax to both sides of the board. Similarly, two methods of impregnating were used. One consisted in a relatively high temperature (350-450°F.) for a short time (10-15 minutes) using infrared radiation on single sheets. The other method involved piling

the coated sheets in a stack as on a skid and then placing them in a heated room or oven at 180 to 200°F. for a period of 1 to 8 hours.

All the impregnations were carried out using five different samples of A-flute corrugating board. All the samples were fabricated with regular or standard grade components, that is, the liners or medium were not sized or treated with wet-strength resin. However, all but Sample 1 were fabricated with water-resistant adhesive although the quality of the adhesion was not satisfactory.

Board samples treated as described above were made up into either R.S.C. boxes or tubes. These were evaluated after exposure to normal humidity, high humidity and after various periods of immersion in water. In addition, a few combined board tests were made.

The results of this study may be summarized as follows:

1. On the 42-26-42 sample made with regular starch adhesive the boxes impregnated with paraffin exhibited compression values at 50 and 85% R.H. which were 30 to 120% higher than the untreated. The higher the wax content, the higher the compression; however, the point of maximum efficiency appears to be at the lower levels of impregnation, since large increases in wax pickup resulted in only small increases in compression. The untreated sample when immersed in water delaminated, whereas the treated samples exhibited 80 to 235-pound compression values.

2. The method of impregnating does not appear to be critical; thus, the most practical method is recommended. This is believed to be hot wax spray application followed by curing in an atmosphere of 180 to 200°F. For this latter, the board may be piled on skids and the air circulated

through since there is no blocking of the sheets.

3. The results obtained on the samples of board fabricated with Hubinger adhesive (waterproof) show that 20% wax impregnation gave almost as high compression as 30-35%. The treated samples exhibited substantially higher compression value at 50% R.H. than did the untreated. When the results after 24 hours are considered, the 42-26-42 with 20-25% wax exhibited tube compression values 200% higher than the untreated or the V_3c; however, the 42-26-42 samples with approximately 60% pick-up of Vinsol wax exhibited values approximately 150% higher. The same general trend may be noted for the 69-33-69 grade board. After 96 hours' water immersion, the treated samples exhibited only slight decrease in compression as compared to that after 24 hours' immersion.

4. In general, the treated samples exhibited combined board tests equal to or greater than the corresponding untreated samples.

5. The results indicate that for greatest efficiency the corrugated board intended for waxing as herein should be fabricated with a waterproof adhesive.

6. The conditions used for the evaluation are considered to be far more severe than would normally be encountered in the wet-packing of poultry. Also, the results speak to the compression characteristics and do not involve the retention of the contents which is also of major consideration. It is suggested that possibly better retention would be obtained if a kraft medium were used in place of the semichemical used herein. The kraft would add retentive strength and it is believed would be more compatible with the paraffin.

7. It is believed that the use of additive should be more fully investigated. The results obtained with small addition of polyethylene looked promising and if petrolatum can be used to replace a portion of the paraffin, the cost of using such a mixture should not be much higher than straight paraffin. It is hoped that the polyethylene will give greater flexibility especially at the scoreline.

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